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RPPR Final Report
as of 08-Nov-2018

Agency Code:

Proposal Number: 67985ELCF **Agreement Number: W911NF-15-1-0571**
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Report Date: 18-May-2016 Date Received: 07-Nov-2018
Final Report for Period Beginning 19-Aug-2015 and Ending 18-Feb-2016
Title: Travel Support to The International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz) in Hong Kong, China
Begin Performance Period: 19-Aug-2015 **End Performance Period:** 18-Feb-2016
Report Term: 0-Other
Submitted By: Xi-Cheng Zhang Email: xi-cheng.zhang@rochester.edu
Phone: (585) 275-0333
Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: **STEM Participants:**

Major Goals: The conference was a great success and with 630 registrants from 37 countries, it is the largest IRMMW-THz conference held in Asia so far. Additionally, the conference had a record number of abstract submissions - over 750. The conference accepted 600 contributed papers and combined with the plenary speakers it had a very high quality technical program.

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Prof. Shen gave a historical talk on the beginning of nonlinear optics and THz spectroscopy. He really made us think how hard was in that time doing nonlinear experimento considering the non availability of high peak power laser sources. First experiments were done with a manually Q-switched ruby laser. Things got better when pulsed dye lasers became available. Also he mentioned that at UC Berkeley he received hard times from the department performance reviewers because they did not see any usefulness in nonlinear optics. This should give us motivation and self confidence when people say to us the same thing about THz science.

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RPPR Final Report
as of 08-Nov-2018

Training Opportunities: Nothing to Report

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI
Participant: Xicheng Zhang
Person Months Worked: 1.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

THE INSTITUTE OF OPTICS

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Director and M. Parker Givens Professor of Optics

HAJIM SCHOOL OF ENGINEERING & APPLIED SCIENCES
UNIVERSITY of ROCHESTER

IRMMW-THz Annual Conference 2015
August 23-28 2015 / Hong Kong

Summary: The conference was a great success and with 630 registrants from 37 countries, it is the largest IRMMW-THz conference held in Asia so far. Additionally, the conference had a record number of abstract submissions - over 750. The conference accepted 600 contributed papers and combined with the plenary speakers it had a very high quality technical program.

CONFERENCE INFORMATION

The 40th International Conference on Infrared, Millimeter and Terahertz Waves (IRMMW-THz) was held at The Chinese University of Hong Kong from 23rd-28th August 2015. IRMMW-THz is the oldest and largest continuous forum devoted to the science and technology of long-wavelength radiation. The scope of the conference includes all scientific and technological activities from millimeter-waves to the terahertz regime and on to the far-infrared region of the electromagnetic spectrum. Presentations at this conference address issues ranging from basic physics, chemistry, electrical engineering and materials science to problems in high frequency circuits and systems, communications, antennas and optics, imaging and spectroscopy, as well as potential applications for the technological advancements. The conference takes turns to be held in Asia, Europe and the US. This is the first time that IRMMW-THz has been held in Hong Kong: Professor MacPherson proposed and won the bid to host the conference during the previous Asia meeting held in 2012 at Wollongong University, Australia.

Following a record number of 750 abstract submissions, over 600 people from academia and industry around the world participated in this year's conference – the largest IRMMW-THz conference in Asia yet! The technical sessions were held over five days, with two plenary lectures each day. The plenary speakers were selected through the technical program committee, chaired by Prof Xi-Cheng Zhang of Rochester University. Of particular note were speakers Prof Ron Shen, from Berkeley University of California, well known for his contributions to non-linear optics, and Professor Philippe Goy, this year's Button Prize winner for his outstanding contributions to terahertz instrumentation and its uses in the understanding of fundamental concepts in physics. Additionally, there were three sessions each day during which five different topic areas were presented in parallel. Indeed, there were slots for a total of 335 talks to be presented as well as a further 300 posters. Coordinating all these contributions is rather challenging and inevitably there were a few last minute rearrangements to be made!

As well as the technical sessions, there were social events to encourage collaborations and brainstorming. These included a welcome reception with a lion dance and eye touching and a dinner during which there was a face changing performance. It was great to see participants enjoying the culture and doing science simultaneously!

There is a tradition of incorporating something representative of the hosting city and a terahertz pulse into a logo for the conference…. Since a dragon is a well-known and auspicious creature in Chinese culture, it was an obvious choice for my team!

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Link to the website for IRMMW-THz 2015: http://www.irmmw-thz2015.org/
Attendee statistics on next page – participants were from 37 countries.
630 Registrants from 37 countries, it is the largest IRMMW-THz conference held in Asia so far! Additionally we had a record number of abstract submissions – 753

Title:	International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz) 2015
Date(s):	August 23-28, 2015
Organizer(s):	Hosted by The Chinese University of Hong Kong
Venue:	Yasumoto International Academic Park, The Chinese University of Hong Kong
Purpose(s):	The International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), is the oldest and largest continuous forum devoted to the science and technology of long-wavelength radiation. The scope of the conference includes all scientific and technological activities from millimeter-waves to the THz regime and on to the far-infrared region of the electromagnetic spectrum. This covers a very wide range of disciplines, encompassing everything from micro- and nano-scale devices and structures to large-scale accelerators and tokamaks and their applications. Presentations at this conference address issues ranging from basic physics, chemistry, electrical engineering and materials science to problems in high frequency circuits and systems, communications, antennas and optics, imaging and spectroscopy, and much, much more. The conference brings together scientists and technologists from more than 30 countries and typically hosts 600-700 participants. Contributed papers are archived on IEEEXplore, and IEEE is a long term technical co-sponsor of the conference series - currently celebrating 40 years since the first event was held in Atlanta, Georgia in 1974. We believe this is an excellent opportunity for researchers and academicians from around the world to come to Hong Kong to meet with the world leading researchers in related areas.
Theme(s):	IR, THz, and MMW in the following areas: 01. Astronomy and Environmental Science 02. Applications in Biology and Medicine 03. Applications in Security and Defense 04. Applications in Industry 05. Spectroscopy and Material Properties 06. Protein Dynamics and Molecular Spectroscopy 07. Spectroscopy of Gases, Liquids, and Solids 08. Sources, Detectors, and Receivers 09. Imaging and Remote Sensing 10. Modeling and Analysis Techniques 11. Metamaterial Structures and Applications 12. Devices, Components, and Systems 13. R&D, Future Applications, and Market Directions 14. High-Field THz Wave Generation and Nonlinear THz Physics 15. Frequency and Time Domain Instruments 16. MMW systems, Transmission Lines and Antennas 17. MMW and Sub-millimeter Wave Radar and Communications 18. Ultra High Speed MMW Digital Devices 19. Laser Driven THz Sources

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	20. Quantum Cascade Lasers 21. Gyro-Oscillators and Amplifiers 22. Free Electron Lasers and Synchrotron Radiation 23. Planetary and Earth Science Applications 24. Applications in Art Conservation studies 25. Ultrafast Measurements 26. Plasma Diagnostics 27. Metrology		
Programme:	This is a 6-day (Aug 23 Sunday – Aug 28 Friday) conference consists of: - 10 Plenary keynote speeches - Technical program with papers presentation - Posters sessions, demo and exhibition sessions for idea exchange - Social programs including welcome reception, award banquet and excursions.		
Plenary speaker(s):	Title	Name	Department / Institution / Country
		Philippe Goy Ron Shen Edmund Linfield Martina Havenith Richard Averitt Tadao Nagatsuma Frank Hegmann Frank Koppens Rupert Huber Xiang Zhang	President of AB Millimetre, 2015 Button Prize, USA UC Berkeley and Fudan Univ, USA University of Leeds, United Kingdom Ruhr-University Bochum, Germany Boston University, USA University of Osaka, Japan University of Alberta, Canada ICFO Barcelona, Spain University of Regensburg, Germany University of California, USA
participants:	630		
Website:	http://www.irmmw-thz2015.org/		

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Attendants from each countries:

Show All entries Search:

Showing 1 to 38 of 38 entries

Total	Country Code	Country Name
127	CN	China
95	JP	Japan
73	HK	Hong Kong
59	US	United States
52	DE	Germany
41	GB	United Kingdom
36	RU	Russian Federation
30	FR	France
30	KR	Korea, Republic of
14	AU	Australia
8	TW	Taiwan
7	CA	Canada
7	IL	Israel
7	PL	Poland
6	CH	Switzerland
6	ES	Spain
6	IN	India
6	IT	Italy
6	NL	Netherlands

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Total	Country Code	Country Name
5	CZ	Czech Republic
5	DK	Denmark
4	LT	Lithuania
4	Unknown	Unknown
3	AM	Armenia
3	MX	Mexico
3	SE	Sweden
3	UA	Ukraine
1	AT	Austria
1	BR	Brazil
1	EE	Estonia
1	HU	Hungary
1	IR	Iran, Islamic Republic of
1	LV	Latvia
1	NZ	New Zealand
1	PH	Philippines
1	RO	Romania
1	SG	Singapore
1	SI	Slovenia

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General achievements (Zhang's group)

During this trip, my PhD student Fabrizio Buccheri was invited to give a one-hour plenary lecture titled "THz wave emission from laser-induced microplasma" during the 5th Shenzhen International Conference on Advanced Science and Technology on August 22nd. He was the only student speaker invited among all the other distinguished scientists.

The other PhD student Kang Liu has won the first place of Best Student Paper/Presentation Award in IRMMW-THz 2015 with her talk on" Study of THz Emission from Ring-Airy Beam Induced Plasma". Her presentation stood out in the competition with 148 applicants, 48 nominees, and 6 finalists. The awarded paper was done under an international collaboration with FORTH, Greece.

Summary from Plenary speakers

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High-field THz wave generation and nonlinear THz physics session

There were 19 papers in four sessions and this report focuses on 8 of them.

1) THz pulses up to millijoule from organic crystal pumped by a Cr:Fosterite laser, **Carlo Vicario, et al**.

The group published a Nature Communication paper on this work, and for the conference they have separated it to two different talks (see the 7th one below). In this talk they have mainly focused on how they generated THz pulse with the peak fields (magnetic in the prackets) reaching 8.3GVm^{-1} (27.7 T) and 6.2GVm^{-1} (20.7 T) from the two kinds of organic crystals, DSTMS and OH1 respectively. This is still the record for THz generation from crystal.

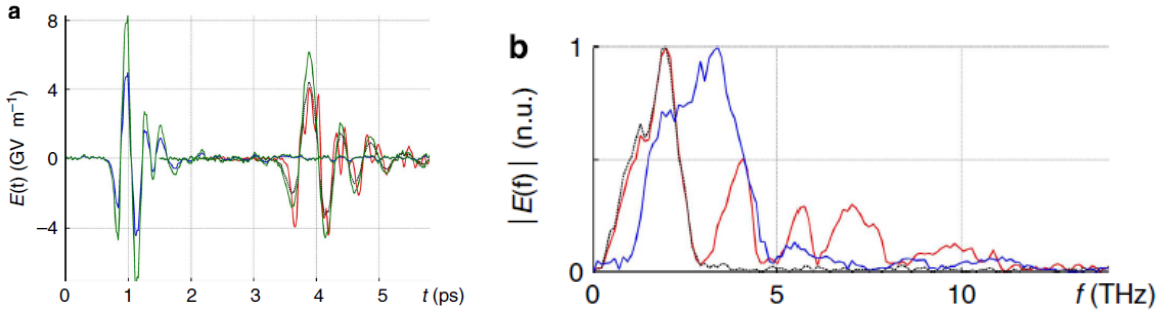

Fig.1 The temporal profiles and spectrum of the THz pulses generated from DSTMS (blue) and OH1 (red and shifted in time). The black curve shows the corresponding temporal profile from OH1 after removing the high-frequency modulations using a 3 THz low-pass filter. The green curves show the estimated THz profile for a focusing mirror without probe hole.

2) Nonlinear refractive index for crystals at terahertz frequencies, **Sergei Kozlov, et al.**

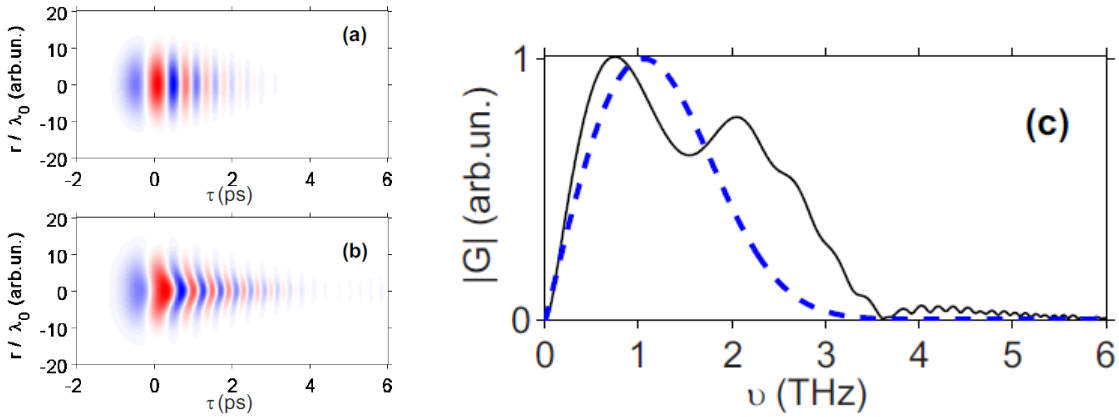

Fig. 2. Spatiotemporal electric output field profiles with initially Gaussian transverse distribution for (a) weak nonlinear and (b) strong nonlinear intensity with the same nonlinearity as crystal quartz and (c) corresponding to strong nonlinear case modulus of the output spectrum at the beam axis. The spectrum of input single-cycle wave at the beam axis is shown by a dashed line.

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This is a collaboration work between ITMO University and Prof. Boyd. This is a pure theoretical work predicting a n_2 for crystalline quartz in the THz spectral range four orders of magnitude larger than the value of n_2 in the visible range.

3) Contact grating device with Fabry-Perot resonator toward intense THz pulse generation by optical rectification, **Masaaki Tsubouchi, et al.**

The Japanese group designed a contact grating device on a piece of LiNbO3 using etching technique. Using pump pulse energy of 3mj, they can generate THz up to 0.27μJ, giving an energy efficiency of 9.0 × 10-5. This will be a nice alternative of conventional pulse tilting THz generation device.

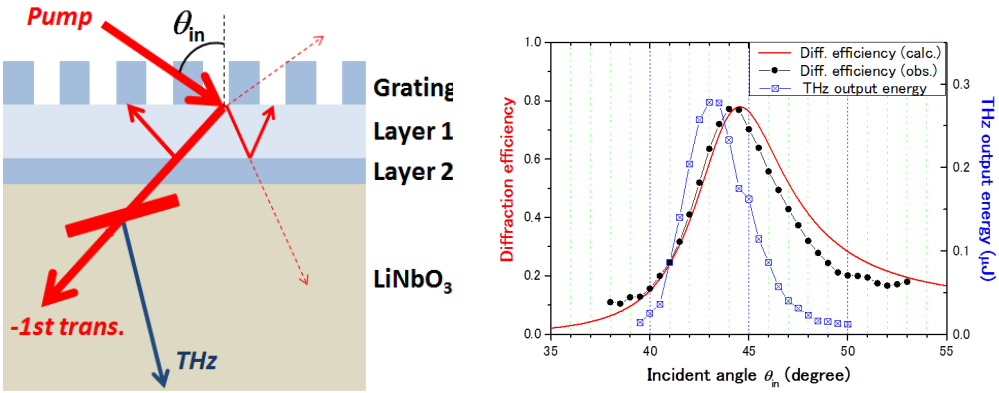

Fig. 3 left:schematic details of the Fabry–Perot type contact grating device. The arrows show the wave vector of light. The thick bars indicate the pulse front; right: Diffraction efficiency and THz output energy as a function of the pump incident angle. The solid line and filled circles show the calculated and experimental diffraction efficiencies, respectively. The open squares indicate the experimental THz output energy measured with pump energy of 3 mJ.

4) Effect of nonlinearity on surface plasmon polaritons in graphene in the Terahertz region, **Matthew Sanderson, et al.**

Prof. Chao Zhang's work on graphene shows the effect of the increase in the field on the reflection coefficient. When the electric field is increased, the dip in the reflection begins to bend, and at a sufficiently high field (≥4kV/cm) an onset of bistability is found to occur. The onset field for bistability is expected to be a function of the chemical potential.

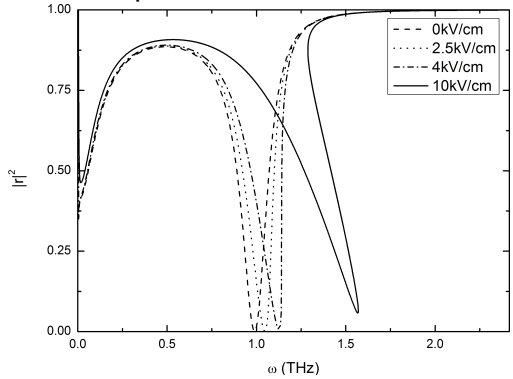

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Fig. 4. Reflection coefficient with increasing field and frequency

5) Out-of-plane THz electric field enhancement in vertical nano-slit arrays, **Y. Waeber, et al.**

Due to the geometry of almost all structures, the electric field component that is enhanced, is normally the in-plane component. The novelty of this work is that they demonstrated the first out-of-plane field enhancement by using multilayer vertical nanoslit arrays.

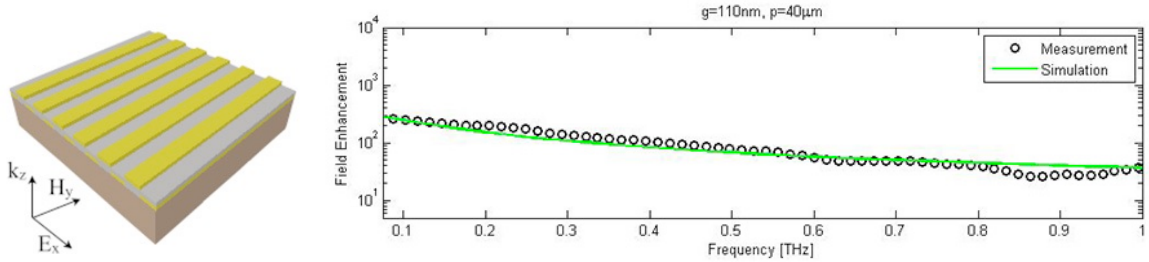

Fig. 5. Left: Schematic illustration of the vertical nano-slit array; right: Field enhancement derived from experimental data (black circles) and corresponding simulation (green curve).

6) Colossal terahertz nonlinearity of angstrom-sized infinite gaps, **Young-Mi Bahk, et al.**

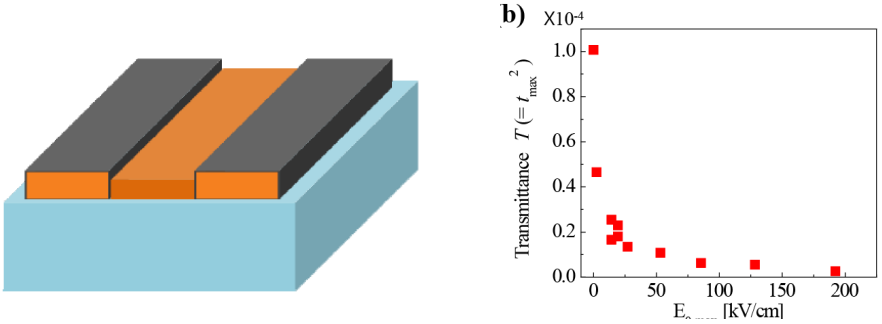

Fig. 6 Left: The angstrom-sized gaps of metal-graphene-metal were made by chemical vapor deposition system and simple adhesive tape based planarization; right: Maximum normalized transmittance as afunction of the incident terahertz electric field.

This group observed 97% decrease of normalized transmittance in a few millimeter long, angstrom-sized gaps at terahertz frequencies. The colossal nonlinearity originates from an intense terahertz funneling facilitating electron tunneling across the gap.

7) Extreme Terahertz brightness by focusing to a lambda-cubic volume, **Mostafa Shalaby, et al.**

In this work they demonstrated bright low-frequency terahertz (<5 THz) radiation confined to a diffraction-limited spot size by wavefront manipulation, providing bright THz radiation at the PW/m^2 level. The result of this work directly gives rise to the data of nonlinearity in the work below. This is a good example of how developing strong THz field can pave the way to nonlinearity study in THz frequency.

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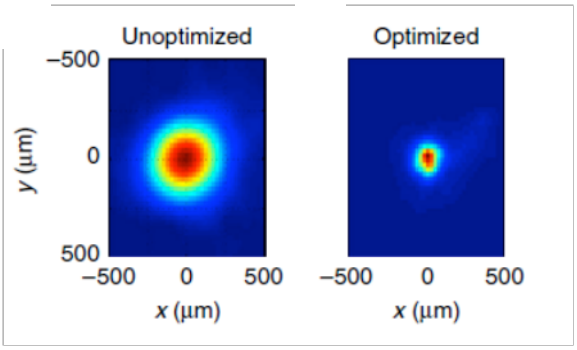

Fig. 7 Unoptimized and optimized THz focus

8) Air Nonlinearity triggered by an ultra-intense sub-5 THz light bullet, **Mostafa Shalaby, et al.**

In this work, they reported on the observation of large-amplitude nonlinearity in air induced by an extremely intense light bullet at THz frequencies provoking strong air birefringence. The pulse they used was 3.9 THz-centered and its peak field and intensity were 3.3 GV/m and 14.4 PW/m^2, respectively. This work reminds me of Jing Zhang's work studying birefringence in air by ABCD.

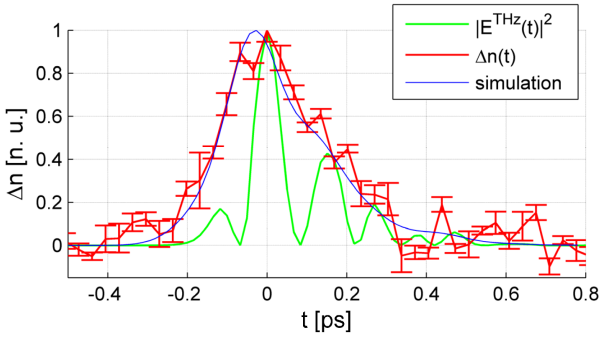

Fig. 8 A comparison between the THz intensity, the measured birefringence and simulations.

Sincerely,

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